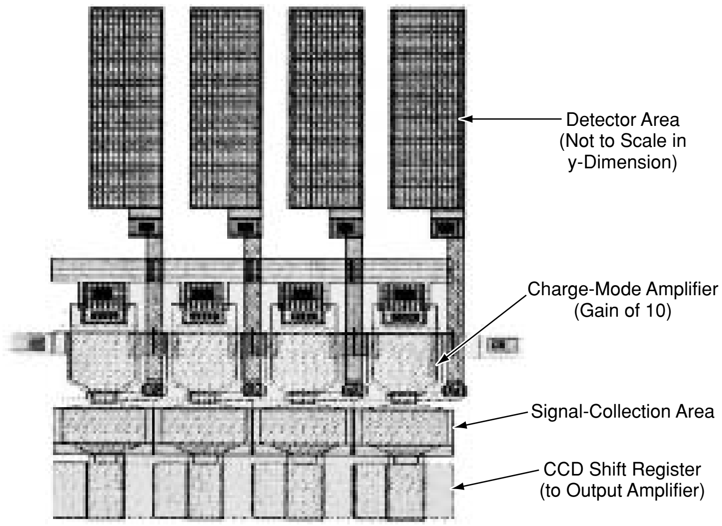

A **Linear CCD Array** contains capacitive charge sensors (instead of photodetectors) in the detector areas. Four representative pixels of the array are shown here. The detector array has many pixels (e.g., 1,024 pixels for 25-mm long array).

filled via diode sources. By appropriate design, the fill-and-spill structure can be made to provide gain in the charge domain. The design under consideration at the time of reporting the information for this article is expected to provide a gain of 10.

The signal charges are clocked through the shift register in basically the same manner as that of a CCD photodetector array. After clocking through the array, the signal charge is presented to a charge-to-voltage-conversion output amplifier. Unlike in some CMOS photodetector circuits, there is only one such amplifier. This feature minimizes variations of signal gain and signal offset among pixels.

This work was done by Mahadeva Sinha and Mark Wadsworth of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP [see page 1].*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Contactless Rotary Electrical Couplings

Efficient inductive couplings are used in place of slip rings.

Ames Research Center, Moffett Field, California

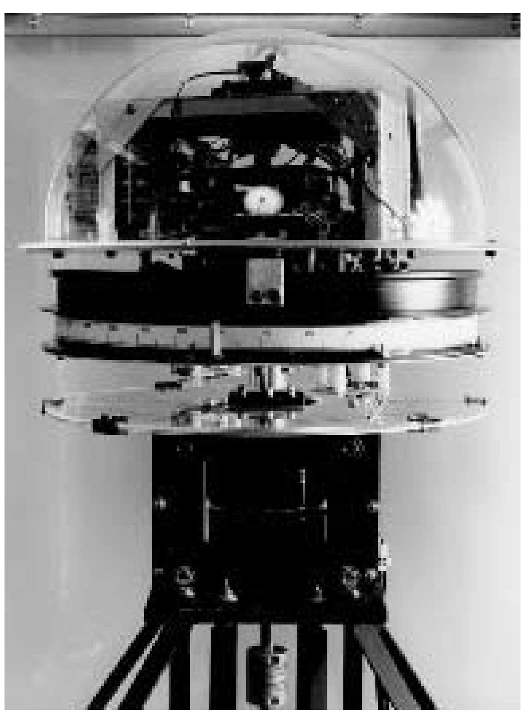

Figure 1. **Transformers, Instead of Slip Rings and Brush Contacts,** are used to couple ac power and data signals between stationary and rotating circuits.

Rotary electrical couplings based on induction (transformer action) rather than conduction between rotating and stationary circuitry have been invented. These couplings provide an alternative to slip rings and contact brushes.

Mechanical imperfections of slip-ring and brush contact surfaces and/or dust particles trapped between these surfaces tend to cause momentary interruptions in electrical contact and thereby give rise to electrical noise. This source of noise can be eliminated in the inductive rotary couplings because no direct contact is necessary for transformer action.

Figure 1 shows an example of the use of a rotary inductive coupling. In this application, it supplies power to a rotating digital data acquisition/transmission system test bed. The rotating data system is shown under the transparent dome and the data is transmitted via free-space optical data transmission through the dome. The rotary inductive coupling is shown in the lower half of the photograph. As in the case of conventional stationary transformers, the levels of power that can be transferred via inductive rotary couplings are limited only by con-

siderations of operating frequencies, sizes, and provisions for dissipation of heat. Typical operating frequencies for transfer of power lie in the same range as that for conventional stationary power transformers — tens to hundreds of hertz. Typical frequencies for coupling of digital data signals tend to lie at the low end of this frequency range.

Figure 2 shows a simplified cross section of a typical inductive rotary coupling between a stationary circuit and a rotating circuit mounted on a motor-driven shaft. The transformer windings comprise a stationary and a rotating coil, both concentric with the axis of rotation. Either coil can serve as the primary winding, with the other serving as the secondary winding. The stationary assembly includes a transformer core that, like a conventional stationary power transformer, is made by stacking sheets of silicon steel or other suitable magnetically "soft" material.

The transformer core partly resembles the core of a common type of conventional power transformer; it includes an inner part framed in a generally rectangular outer part. However, unlike the core of a conventional power transformer, this core includes a clearance hole for the rotating shaft, and the inner core is a round cylinder (instead of a rectangular solid) with the clearance hole lying along its axis. Moreover, there is a gap at one end of the inner core to provide clearance for a clamp that attaches the rotating coil to the shaft. Both coils are annular, with inner radii and outer radii to fit the recess between the inner and outer core. To provide clearance for rotation, the inner radius of the stationary coil must be made somewhat greater than the outer radius of the inner part of the core.

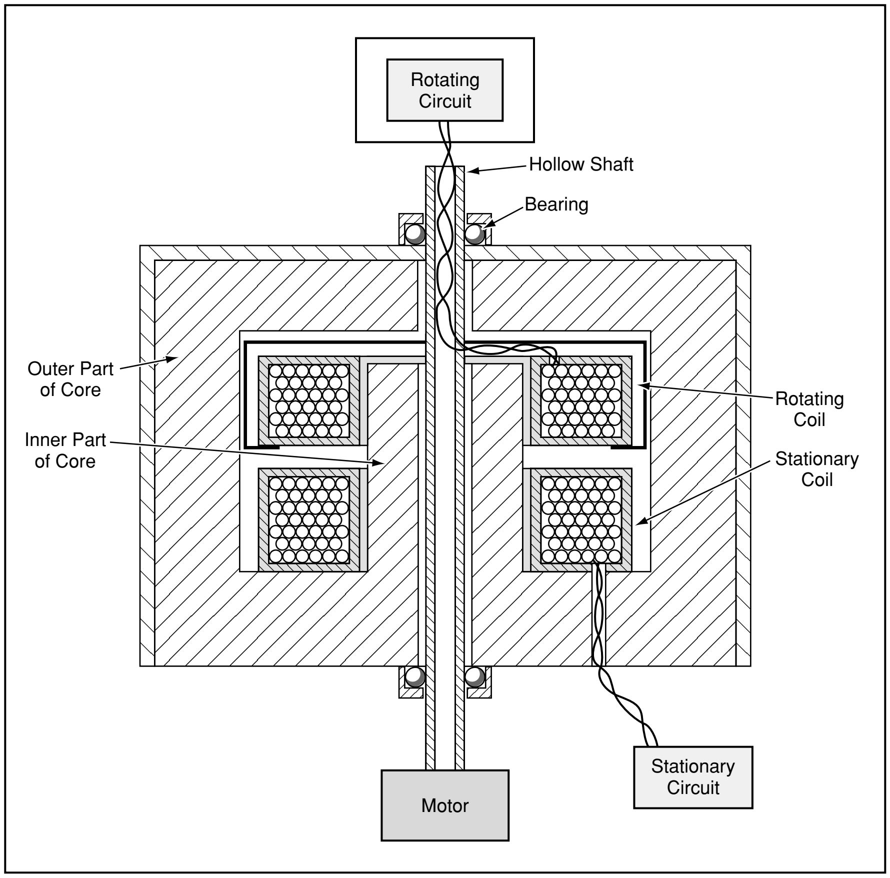

Figure 2. This **Inductive Rotary Coupling** resembles a conventional stationary transformer, except that one coil rotates with a shaft that passes through the middle, and the core is shaped to accommodate the rotating parts. The hollow shaft accommodates the wires that connect the rotating coil with the rotating circuit at one end of the shaft.

This work was done by Hiroyuki Kumagai of Aerospace Computing, Inc., for **Ames Research Center**. *Further information is contained in a TSP [see page 1].*

This invention has been patented by NASA (U.S. Patent No. 5,691,687). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center [see page 1]. Refer to ARC-12072.